Dynamics of Monolayer Nanocrystal Self-Assembling Process in Liquid Film

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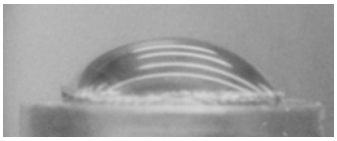
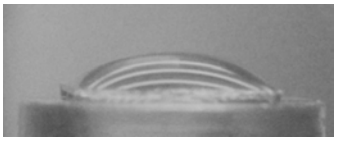
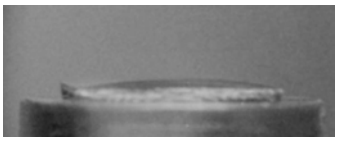
Motivation

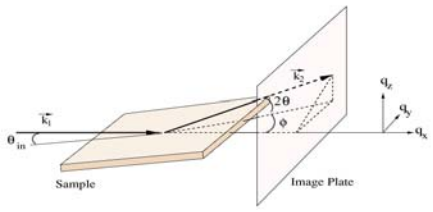
Hierarchical self-assembly is a process that nature adopts to form much of the macroscopic world around us. A variety of systems display domain pattern formation in equilibrium, but in many cases, far away from equilibrium. We use GISAXS technique to investigate the dynamics of the formation of a highly ordered nanocrystal monolayer through evaporation of a nanocrystal colloidal droplet.



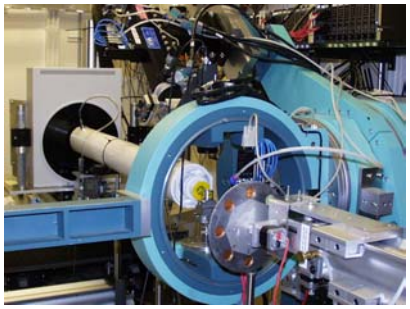




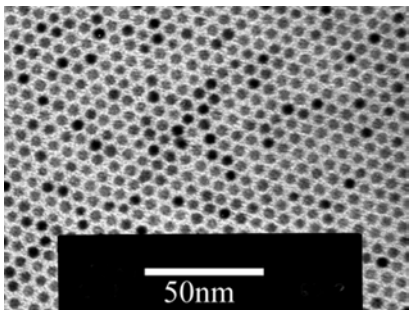
Experimental Technique



Grazing Incidence Small Angle X-ray Scattering (GISAXS)

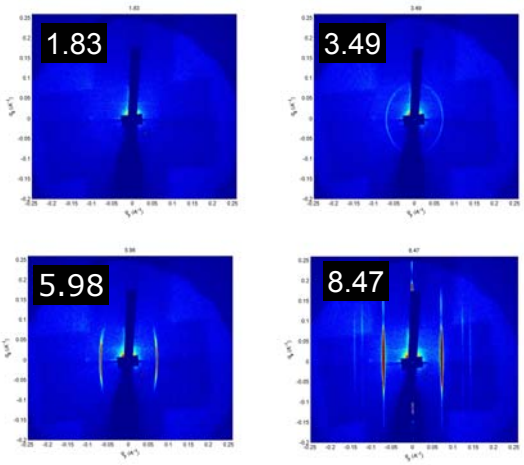


Highly Ordered Nanocrystal Monolayer

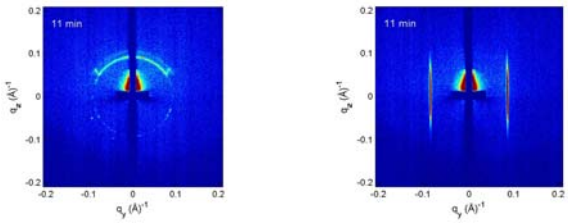


Experimental Results

In situ GISAXS patterns (unit = minutes):



Slow Evaporation vs. Fast Evaporation



- Kinetic effects can play an important role in nanocrystal self assembly.
- Fast initial evaporation rate can induce nanocrystals accumulate at the liquid-air interface and undergo a 3D to 2D structural transition to form highly ordered nanocrystal monolayer.
- Slow initial evaporation rate allows nanocrystals to diffuse into the bulk part of liquid layer and aggregate into 3D superlattices once the concentration of nanocrystal exceed critical concentration.

Impact

- This is a first *in situ* experiment of this kind to investigate the self-assembly process
- The experiment discovered an unique growth process of nanocrystal superlattices

Future Directions

- Control of 2D nucleation and domain growth.
- Determine critical evaporation rate of 3D to 2D transition.
- Generalize the kinetic self-assembling process to different systems

This work has been submitted to Nature Materials and is currently under review.

BES - DOE

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